parison by hours per day we must remember, and allow for, the fact that the sun works only half the day, on the

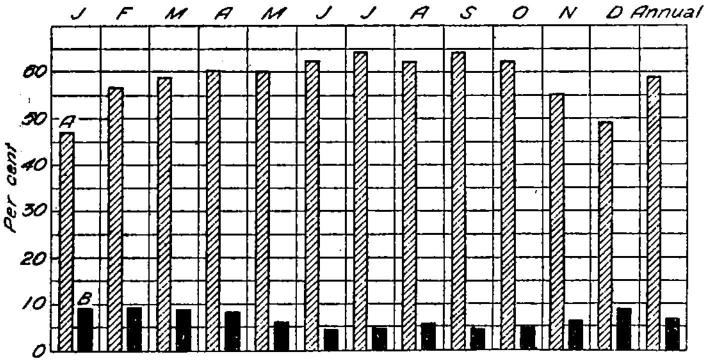

FIGURE 3.—Duration of sunshine and of precipitation, percentage of possible, Baltimore, Md. (A) Sunshine. (B) Precipitation

average, while rainfall is possible throughout the 24 hours. In a word, it is found that bright sunshine occurs nine times as much of the possible time as rainy weather occurs, taking the year round, at Baltimore; that is, the rainfall duration percentage of the possible for the year is 6.4 per cent, while the bright sunshine hours total 58.0 per cent of the possible.

TABLE 1.—*Total duration (hours) of precipitation, excluding hours with only traces, Baltimore, Md. (1919–1927)*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1918	68.5	27.3	65.2	114.3	25.6	26.6	26.5	21.3	48.4	16.7	18.4	64.6	523.4
1919	65.8	57.7	70.2	38.9	66.8	22.5	57.6	35.2	14.4	67.2	65.5	70.7	632.5
1920	79.4	90.3	63.1	77.8	37.3	48.8	19.7	80.5	30.2	5.0	56.3	48.7	637.1
1921	46.5	53.0	48.4	48.9	73.3	13.9	29.3	29.6	14.2	23.9	82.3	47.9	511.2
1922	67.3	72.9	85.2	24.2	46.5	40.0	37.8	23.7	17.1	20.6	8.7	67.7	511.7
1923	67.7	59.0	71.1	60.2	25.0	17.7	29.5	33.5	32.3	30.3	41.5	76.6	544.4
1924	37.7	52.0	90.5	58.4	84.4	36.3	15.3	28.1	83.2	1.8	21.7	41.5	550.9
1925	93.6	26.7	51.6	50.8	15.6	18.6	35.2	29.4	11.5	76.2	46.3	46.4	501.9
1926	70.5	81.8	54.2	29.4	25.0	21.3	51.9	70.7	47.7	36.7	49.4	68.4	607.0
1927	42.4	69.2	29.5	71.1	42.5	47.8	20.5	45.0	11.6	67.0	32.7	72.5	551.8
Mean	63.9	59.0	62.9	57.4	44.2	29.4	32.3	39.7	31.1	34.5	42.3	60.5	557.2

TABLE 2.—*Average total duration (hours) of precipitation, excluding traces, Baltimore, Md. (1919–1927)*

	A. M.												P. M.											
	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Midnight
January	2.5	2.8	3.0	2.7	2.6	3.4	3.3	3.6	2.8	2.7	3.0	3.1	2.3	2.7	2.7	2.4	2.1	2.1	2.5	2.6	2.0	1.9	2.5	2.7
February	2.8	2.8	2.8	3.2	2.7	2.6	3.0	3.1	2.7	2.7	2.7	2.3	2.0	2.3	2.1	2.1	1.9	1.6	1.6	1.9	2.1	2.9	2.5	2.5
March	2.4	2.3	3.1	3.1	2.8	2.8	2.8	2.9	3.0	2.7	2.5	2.9	3.0	2.5	2.6	2.6	1.9	2.5	2.2	2.4	2.5	2.7	2.0	2.7
April	2.2	2.5	2.4	2.1	1.9	1.9	2.4	2.6	2.4	2.5	2.5	1.8	1.8	2.3	2.5	2.6	2.4	2.2	2.3	2.8	2.8	2.8	2.9	2.9
May	1.4	1.7	1.7	2.2	2.0	2.2	1.8	1.6	1.4	1.3	1.4	1.7	1.5	1.3	2.0	1.9	2.1	2.0	2.4	2.5	1.6	2.3	2.2	2.1
June	1.5	1.3	1.3	0.8	1.0	0.8	1.0	1.0	0.6	0.8	0.7	1.0	1.0	1.4	1.0	1.3	1.4	1.4	1.5	1.7	2.0	1.6	1.7	1.5
July	1.3	1.7	1.3	1.1	1.1	1.4	1.5	1.1	1.4	0.8	0.5	0.5	1.1	1.6	1.5	1.5	2.4	1.7	1.2	1.4	1.9	1.7	1.5	1.2
August	1.6	1.5	1.5	1.1	1.7	2.0	2.3	1.7	1.7	1.4	1.6	1.5	1.7	1.7	1.1	1.4	1.2	2.3	1.9	2.0	2.0	1.6	1.8	1.5
September	1.4	1.0	1.2	1.0	1.2	1.3	1.5	1.4	1.0	1.2	1.2	1.0	1.1	1.2	1.2	1.2	1.2	1.3	1.5	1.9	1.5	1.4	1.5	1.3
October	1.1	1.1	0.6	1.2	1.2	1.2	1.4	1.5	1.6	1.9	1.6	2.2	2.0	2.1	1.7	1.4	1.4	1.5	1.5	1.3	1.4	1.4	1.0	1.2
November	2.1	2.3	2.1	2.1	1.6	1.8	1.5	1.2	1.8	1.5	1.6	1.7	2.1	1.6	1.9	2.2	1.8	1.7	1.7	1.7	1.6	1.7	1.5	1.6
December	3.2	2.7	3.0	3.2	3.4	3.4	3.2	2.7	2.4	2.5	2.2	2.1	2.5	2.3	2.6	2.3	2.1	2.0	2.0	1.7	2.0	2.3	2.5	2.4
Mean	2.0	2.0	2.0	2.0	1.9	2.1	2.1	2.0	1.9	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.8	1.9	1.9	2.0	2.0	2.0	2.0	2.0

A SIMPLE METHOD OF MEASURING THE DIFFUSED RADIATION OF THE SKY ACCORDING TO ZONES

551.590.2 : 551.508.2

By Prof. N. N. KALITIN

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The solar radiation diffused by the atmosphere is generally measured for the whole vaulted sky. Meanwhile the study of this radiation, not as total for the whole vault, but with regard to the several zones, presents a great interest, as much theoretical as practical.

I should like to give in this short note a description of a simple method applied by me for the above purpose. I made use of the well-known pyranometer of A. Ångström, a splendid instrument, giving, if shaded from the sun by a small screen, the intensity of solar radiation diffused by the atmosphere.

The complete installation is shown in Figure 1; the principle of its action is the following: The pyranometer is placed on the line of the axis of the cylinder B, the latter being subject ad libitum to being raised or lowered, and fixed in position by means of the screw H. If the upper rim of the cylinder be placed at the level of the plane within which are disposed the receiving plates of the pyranometer, the apparatus will be subjected to the effect of radiation from the whole vault of the sky. As the cylinder B is shifted higher and higher the vault is more and more covered, beginning with parts adjacent to the horizon, so that they will have no effect on the pyranometer.

The dimensions of the cylinder B being known, it is easy to compute beforehand the height at which the cylinder B must be placed so as to cover the vault to 10°, 20°, 30°, etc., from the horizon.

The installation constructed by me allows a covering of the sky by means of shifting the cylinder up to 60°. For a further screening of the sky a higher cylinder might be used; but as this is inconvenient I adopted the following proceeding: The cylinder B being adjusted at the height to screen the sky up to 60°, it is partly closed by the cover C, which has a round opening and screens the sky up to 70° from the horizon. If the cover D be substituted for the cover C, the sky is shaded up to 80°.

Thus the above adjustment permits us to measure the radiation of the whole vault as well as its several parts in the form of circular zones of any desired width. The cylinder B as well as the covers C and D have been lined with black velvet in order to avoid all possible reflection.

The ingenious arrangement of the receiving surfaces of A. Ångström's pyranometer eliminates any possibility

(To face p. 52)

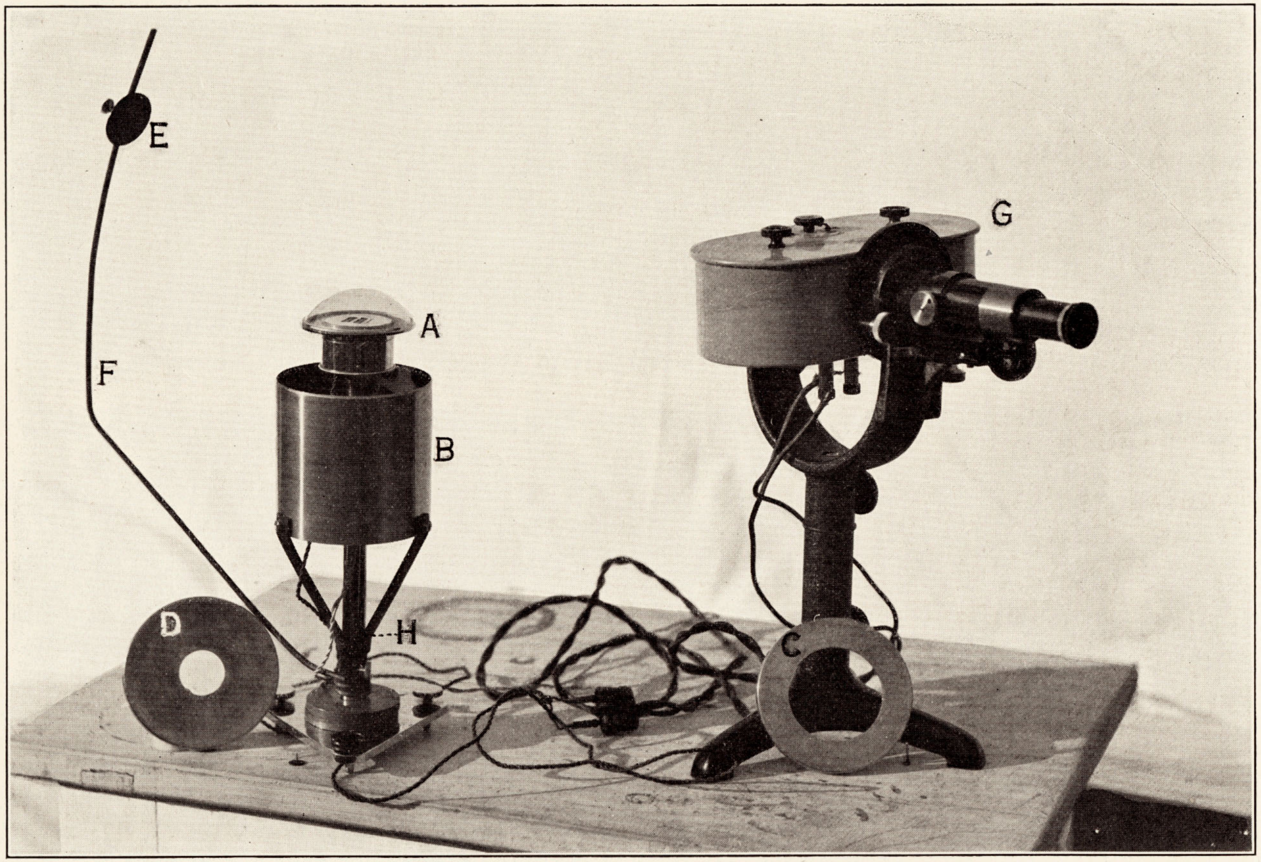

FIGURE 1.—Pyranometer A. Ångström, together with the loop galvanometer Zeis, adjusted for measurements of diffused radiation of the vaulted sky according to zones

of the effect of radiation from the outer side of the cylinder and the covers.

In the presence of solar radiation the pyranometer, as it is generally used, is shaded from direct rays of the sun by a small round screen (E), moving on a support (F).

For the measurement of radiation according to zones this pyranometer was applied by me as a relative apparatus together with the Schleifengalvanometer of C. Zeiss, G. With this galvanometer the whole process of measuring the radiation by zones 10° in width, the determination of radiation from the whole sky and also the verification of the position of the zero of the galvanometer before and after a series of observations, could be effected in three to four minutes. The advantage of the Zeiss galvanometer is that, by means of a turning over of the box 180°, its sensibility can be several times increased. For instance, my Ångström pyranometer No. 29 in connection with the Zeiss galvanometer in normal position gave for one division of the galvanometer the value of 0.0081 calorie; whereas with the same glavanometer with the box overturned, it gave 0.0025 calorie; which is especially valuable for observations during an expedition; and my experience enables me to heartily recommend the use of this galvanometer together with the Ångström pyranometer for expedition work.

As has been stated, measurement of radiation by zones can be effected for the whole sky in three to four minutes; the work has necessarily to be completed in a short interval of time, in order that the radiation of the vault shall not change materially during the measurement. In most cases the change is not material within so short a space of time, except in rare cases of an exceptionally rapid drift of clouds, when the radiation is apt to change considerably within a few minutes; then measurements of radiation according to zones ought not to be made.

I give here, as an example, four lines of measurements of radiation according to zones—two regarding a sky free of cloud and two for a sky covered with a dense sheet of cloud.

Table 1.—*Distribution of diffused radiation of the vaulted sky according to zones of a clear (entirely free of cloud) and an overcast sky*

Hours of observations	9_+	h☉	A	0°–10°	10°–20°	20°–30°	30°–40°	40°–50°	50°–60°	60°–70°	70°–80°	80°–90°
Sky free of cloud:	*cal.*	°	*P. ct.*									
Sept. 22, 1928, 9h. 17m	0. 080	26. 6	100	5. 3	12. 2	16. 2	17. 7	16. 5	13. 7	9. 3	5. 6	3. 1
Sept. 19, 1928, 10h. 23 m	. 068	18. 4	100	7. 6	15. 0	16. 9	16. 4	13. 2	12. 8	9. 5	6. 1	2. 5
Cloudiness (10 SCu):												
Oct. 21, 1928, 12h. 55m	. 084	18. 2	100	3. 1	5. 6	10. 8	15. 0	16. 5	16. 2	18. 3	10. 2	4. 2
Dec. 12, 1928, 11h. 33m	. 048	7. 1	100	4. 2	5. 3	10. 6	13. 2	12. 7	15. 9	18. 5	13. 8	5. 8

Explanation to the table:

9_+. Diffused radiation of the whole vault on a cm². of horizontal surface in 1 minute in gr. cal.

h☉ Altitude of the sun at the middle moment of observation.

A. Radiation of the whole vault (9.) taken for 100 per cent.

0°–10°, 10°–20°, etc., to 80°–90°. Radiation of respective zones of the vaulted sky; from the horizon to the height of 10° and so on up to 80° and from 80° height to the zenith—in per cent of the total radiation of the vault.

In Figure 2 the values of the table are given graphically and show that the distribution of radiation over the vault for a sky free of cloud differs from that regarding an overcast sky. In the first case the maximum falls on the zone 30°–40° and in the second on the zone 60°–70°. Besides, in the presence of a clear sky the zone adjacent to the horizon radiates more than the zone round the zenith, whereas the sky being overcast the case proves vice versa. After C. Abbot, H. Kimball, W. Dines, and C. Dorno's investigations, this is generally known, and I only want to show that by means of a very simple method here exposed it is possible to obtain the same results which are generally attained by more intricate procedures.

The exposed method allows an organization of systematic observation on the radiation of the several zones of the vaulted sky. The results obtained supply many valuable data regarding the effect of various meteorological elements and topographical features on the diffused radiation, as well as its dependence upon the height of the sun over the horizon.

Series of these observations may prove very valuable for health resorts and also for agricultural purposes (e. g., for the study of the effect on growing vegetation of the

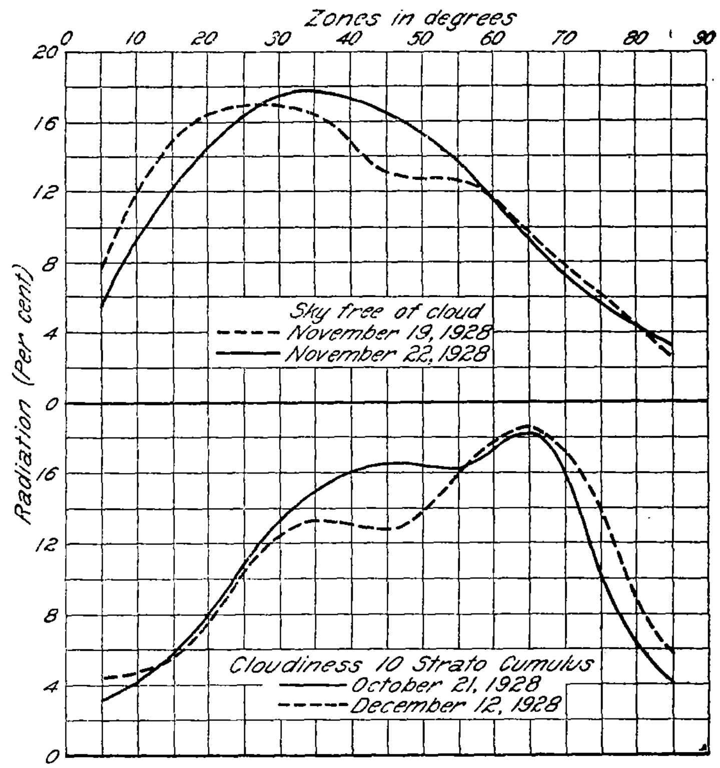

Figure 2.—Distribution of diffused radiation of the vaulted sky according to zones

shading of the lower position of the vaulted sky in woodland, meadows, mountain valleys, etc.).

DISCUSSION

By Herbert H. Kimball

Professor Kalitin has pointed out a simple way to measure the intensity of the solar radiation received diffusely from the sky with apparatus easily obtainable. A method similar in principle has been employed by the Astrophysical Observatory at the Smithsonian Institution in measuring radiation from horizontal sky zones 30° in width; also from a ring 60° in diameter concentric with the sun, and from similar areas of equal dimensions and altitude located 60°, 120°, and 180°, respectively, from the sun.[1] The objection to these methods is that since the receiving surface of the pyrheliometric device employed has definite dimensions, different parts of it will be exposed to different sky zones. The smaller the dimensions of this receiving surface the less will be the

[1] Moore, A. F., and Abbot, L. H. 1920. The Brightness of the Sky. Smithsonian Miscellaneous Collections, vol 71, No. 4.